

# Claims

- [c1] 1. An apparatus, comprising:  
a product carrier adapted to transport product undergoing manufacture; and  
a first device adapted to sense an attribute of an environment within said product carrier or an event affecting said product carrier.
- [c2] 2. The apparatus of claim 1, further comprising:  
a second device adapted to receive said attribute or event data sensed by said first device and to transmit said attribute or event data.
- [c3] 3. The apparatus of claim 2, wherein said first device and said second device are the same device.
- [c4] 4. The apparatus of claim 2, wherein said first device is contained within said product carrier or said first device and said second device are contained within said product carrier.
- [c5] 5. The apparatus of claim 1, further including means for sending said attribute or event data to a location external to said product carrier.

- [c6] 6. The apparatus of claim 1, wherein said product carrier is adapted to be sealed against the surrounding atmosphere of a manufacturing facility that said product is being manufactured in.
- [c7] 7. The apparatus of claim 2, wherein said second device is programmable with at least a unique product carrier identity and is adapted to transmit said product carrier identity with said attribute or event data.
- [c8] 8. The apparatus of claim 1, further including additional devices, each additional device adapted to sense one or more additional attributes of the environment within said product carrier or an event affecting said product carrier.
- [c9] 9. The apparatus of claim 8, further comprising:  
a second device adapted to receive said attribute or event data sensed by said first device and by said additional devices and transmit said attribute or event data.
- [c10] 10. The apparatus of claim 1, wherein said attribute of said environment within said product carrier or an event affecting the product carrier is selected from the group of attributes and events consisting of temperature, pressure, humidity, particulate count, the presence of oxygen, hydrogen, chlorine, elemental gases, ammonia, wa-

ter vapor, hydrogen fluoride, hydrogen chloride, nitrogen oxides, silanes, alcohols, ketones, esters, amines, solvents, chlorinated solvents and fluoridated solvents, the occurrence of vibration, acceleration and shock, the intrusion of visible light, ultra-violet light, infrared light and microwaves, and electromagnetic events and static electric charge buildup.

[c11] 11. The apparatus of claim 1, wherein a product within said product carrier is selected from the group of products consisting of semiconductor substrates and wafers, photolithography masks, photolithography reticles, semiconductor modules, semiconductor packages, circuit boards, magnetic disks, magnetic hard drive disks, magnetic floppy disks, laser disks, compact disks, digital video disks, optical disks, lenses and mirrors.

[c12] 12. A method of monitoring an internal environment of a product carrier or events affecting said product carrier in a manufacturing facility, comprising:  
providing said product carrier, said product carrier transporting product undergoing manufacture; and  
providing a first device sensing an attribute of the internal environment of said product carrier or an event affecting said product carrier.

[c13] 13. The method of claim 12, further comprising:

providing a second device, said second device receiving said attribute or event data sensed by said first device; and  
transmitting said attribute or event data.

[c14] 14. The method of claim 13, further including transmitting said attribute or event data to a location external to said product carrier.

[c15] 15. The apparatus of claim 13, wherein said first device is contained within said product carrier or said first device and said second device are contained within said product carrier.

[c16] 16. The method of claim 13, wherein said first device and said second device are the same device.

[c17] 17. The method of claim 12, further including sealing said product carrier from the surrounding atmosphere of said manufacturing facility.

[c18] 18. The method of claim 13, further including:  
programming said second device with at least a unique product carrier identity; and  
transmitting said product carrier identity with said attribute or event data.

[c19] 19. The method of claim 12, further including providing

additional devices, each additional device for sensing one or more additional attributes of the environment within said product carrier or an event affecting said product carrier.

- [c20] 20. The method of claim 19, further comprising:
- providing a second device;
  - said second device receiving said attribute or event data sensed by said first device and by said additional devices; and
  - said second device transmitting said attribute or event data.
- [c21] 21. The method of claim 12, wherein said attribute of said environment within said product carrier or an event affecting the product carrier is selected from the group of attributes and events consisting of temperature, pressure, humidity, particulate count, the presence of oxygen, hydrogen, chlorine, elemental gases, ammonia, water vapor, hydrogen fluoride, hydrogen chloride, nitrogen oxides, silanes, alcohols, ketones, esters, amines, solvents, chlorinated solvents and fluoridated solvents, the occurrence of vibration, acceleration and shock, the intrusion of visible light, ultra-violet light, infrared light and microwaves, and electromagnetic events and static electric charge buildup.

[c22] 22. The method of claim 12, wherein a product within said product carrier is selected from the group of products consisting of semiconductor substrates, 100mm semiconductor substrates, 200 mm semiconductor substrates, 300 mm semiconductor substrates, 450 mm semiconductor substrates, wafers, 100 mm diameter wafers, 150 mm diameter wafers, wafers 200 mm diameter wafers, 300 mm diameter wafers, 450 mm diameter wafers, photolithography masks, photolithography reticles, semiconductor modules, semiconductor packages, circuit boards, magnetic disks, magnetic hard drive disks, magnetic floppy disks, laser disks, compact disks, digital video disks, optical disks, lenses and mirrors.

[c23] 23. A manufacturing system comprising:  
a multiplicity of manufacturing tools;  
a multiplicity product carriers having micro-sensors, each product carrier adapted to transport product undergoing manufacture between said manufacturing tools, and each micro-sensor adapted to sense at least one attribute of an environment within each product carrier or an event affecting each product carrier, and each micro-sensor adapted to transmit date and time stamped product carrier identity and attribute and event data; and  
one or more receiving stations, each receiving station

adapted to receive said product carrier identity and attribute and event.

[c24] 24. The system of claim 23, further including a production control system adapted to track the manufacturing tool location of said product carriers and to generate date and time stamped product carrier location data.

[c25] 25. The system of claim 24, further including a product carrier monitoring system adapted to collect said date and time stamped product carrier identity and attribute and event data, cross-reference said date and time stamped product carrier location data with said date and time stamped product carrier identity and attribute and event data and generate date and time stamped product carrier identity, attribute and event, and product carrier location data.

[c26] 26. The system of claim 25, wherein said product carrier monitoring system is adapted to generate flags based on said attribute and event data.

[c27] 27. The system of claim 26, further including a statistical process control system adapted to generate an analysis of said attribute and event data.

[c28] 28. The system of claim 27, wherein said statistical process control system is further adapted to transfer said

analysis of said attribute and event data to said production control system.

[c29] 29. The system of claim 23, wherein said attribute of said environment within said product carrier or an event affecting the product carrier is selected from the group of attributes and events consisting of temperature, pressure, humidity, particulate count, the presence of oxygen, hydrogen, chlorine, elemental gases, ammonia, water vapor, hydrogen fluoride, hydrogen chloride, nitrogen oxides, silanes, alcohols, ketones, esters, amines, solvents, chlorinated solvents and fluoridated solvents, the occurrence of vibration, acceleration and shock, the intrusion of visible light, ultra-violet light, infrared light and microwaves, and electromagnetic events and static electric charge buildup.

[c30] 30. The system of claim 23, wherein a product within said product carrier is selected from the group of products consisting of semiconductor substrates, 100mm semiconductor substrates, 200 mm semiconductor substrates, 300 mm semiconductor substrates, 450 mm semiconductor substrates, wafers, 100 mm diameter wafers, 150 mm diameter wafers, wafers 200 mm diameter wafers, 300 mm diameter wafers, 450 mm diameter wafers, photolithography masks, photolithography reticles, semiconductor modules, semiconductor packages,



circuit boards, magnetic disks, magnetic hard drive disks, magnetic floppy disks, laser disks, compact disks, digital video disks, optical disks, lenses and mirrors.

[c31] 31. A method of monitoring an internal environment of a product carrier or events affecting said product carrier in a manufacturing facility comprising a multiplicity of manufacturing tools, the method comprising:

providing a multiplicity product carriers having micro-sensors, each product carrier adapted to transport product undergoing manufacture between said manufacturing tools, and each micro-sensor adapted to sense at least one attribute of an environment within each product carrier or an event affecting each product carrier, and each micro-sensor adapted to transmit date and time stamped product carrier identity and attribute and event data; and

providing one or more receiving stations, each receiving station for receiving said product carrier identity and attribute and event data.

[c32] 32. The method of claim 31, further including providing a production control system for tracking the manufac-

turing tool location of said product carriers and for generating date and time stamped product carrier location data.

[c33] 33. The method of claim 32, further including providing a product carrier monitoring system for collecting said date and time stamped product carrier identity and attribute and event data, cross-referencing said date and time stamped product carrier location data with said date and time stamped product carrier identity and attribute and event data and generating date and time stamped product carrier identity, attribute and event, and product carrier location data.

[c34] 34. The method of claim 33, further including said product carrier monitoring system generating flags based on said attribute and event data.

[c35] 35. The method of claim 34, further including providing a statistical process control system for generating an analysis of said attribute and event data.

[c36] 36. The method of claim 35, further including transferring said statistical process control system said analysis of said attribute and event data to said production control system.

[c37] 37. The method of claim 31, wherein said attribute of

said environment within said product carrier or an event affecting the product carrier is selected from the group of attributes and events consisting of temperature, pressure, humidity, particulate count, the presence of oxygen, hydrogen, chlorine, elemental gases, ammonia, water vapor, hydrogen fluoride, hydrogen chloride, nitrogen oxides, silanes, alcohols, ketones, esters, amines, solvents, chlorinated solvents and fluoridated solvents, the occurrence of vibration, acceleration and shock, the intrusion of visible light, ultra-violet light, infrared light and microwaves, and electromagnetic events and static electric charge buildup.

- [c38] 38. The method of claim 31, wherein a product within said product carrier is selected from the group of products consisting of semiconductor substrates, 100mm semiconductor substrates, 200 mm semiconductor substrates, 300 mm semiconductor substrates, 450 mm semiconductor substrates, wafers, 100 mm diameter wafers, 150 mm diameter wafers, wafers 200 mm diameter wafers, 300 mm diameter wafers, 450 mm diameter wafers, photolithography masks, photolithography reticles, semiconductor modules, semiconductor packages, circuit boards, magnetic disks, magnetic hard drive disks, magnetic floppy disks, laser disks, compact disks, digital video disks, optical disks, lenses and mirrors.

